

# SOME CESTODE PARASITES OF THE ELASMOBRANCHS *RAJA BATIS* AND *SQUALUS ACANTHIAS* FROM ICELAND

By B. R. MANGER

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## SUMMARY

SEVERAL Cestode parasites were collected from five specimens of skate (*Raja batis*) and seven piked dogfish (*Squalus acanthias*), caught off the Western coasts of Iceland. The skate yielded seven species of Tetraphyllidean Cestodes, including three new species, all of which are new records for the area. The worms described are *Acanthobothrium parvum* sp. nov., *A. icelandicum* sp. nov., *Acanthobothrium* sp. innom., *Echeneibothrium dubium* Beneden, 1858, *E. minutum* Williams, 1966, *E. faxanum* sp. nov. and *Phyllobothrium* sp. innom. *A. parvum* sp. nov. is a small worm with between 64 and 79 testes, and has hooks measuring from 0.116 to 0.144 mm in length, a combination not found in any other species of *Acanthobothrium*. *A. icelandicum* sp. nov. is very similar to *A. septentrionale* Baer & Euzet, 1962, but differs in having only one accessory sucker to each bothridium (instead of three), an 'H'-shaped ovary, and a distinct vaginal sphincter. *E. faxanum* has 20 to 26 testes, a well-formed myzorhynchus, and 14 loculi to each bothridium, this last feature distinguishing the worm from *E. variabile* Beneden, 1849, with which it has some similarities. An examination of the spiral valve of *S. acanthias* showed the presence of *Gilquinia squali* (Fabricius, 1794) in four of the fishes, whilst *Trilocularia*

*acanthiaevulgaris* (Olsson, 1867) was found in the spiral valve, or stomach, or in both organs of every piked dogfish collected. Both of these worms are very common parasites of *S. acanthias* and the latter has previously been recorded from Icelandic waters.

#### INTRODUCTION

In October 1966, when on the staff of the British Museum (Natural History), the author was given the opportunity of accompanying the M.A.F.F. Research Vessel 'Clione' on a cruise to Iceland.

Although the parasites of fishes from Icelandic waters have been little studied, it was proposed to restrict investigations to the Cestodes of the Elasmobranchs found in this region.

During the course of the cruise a total of forty-three trawls were made on all but the Northern coasts of Iceland. Every Elasmobranch netted throughout the voyage was collected, comprising in all some twenty-two *Raja radiata*, five *Raja batis* and seven *Squalus acanthias*. However, in the present paper only *R. batis* and *S. acanthias* will be considered, these being caught on the Western coasts and mainly in Faxa Bay.



FIG. 1. Geographical distribution of fishes examined.

Fish	Length	Locality	Depth (Fathoms)	Date
<i>Squalus acanthias</i>	75 cm	63°31' 20°54' (Vestermann Is.)	50	20.x.66
<i>Raja batis</i>	61 cm	64° 38' 23° 39' (Faxa Bay)	57-60	21.x.66
<i>S. acanthias</i>	90 cm	64°22' 22°33' (Faxa Bay)	41-44	21.x.66
<i>R. batis</i>	48 cm	" " "	"	"
<i>R. batis</i>	65 cm	64°18' 22°20' (Faxa Bay)	35-37	22.x.66
<i>S. acanthias</i>	84 cm	" " "	"	"
<i>S. acanthias</i>	85 cm	" " "	"	"
<i>S. acanthias</i>	76 cm	" " "	"	"
<i>S. acanthias</i>	84 cm	64°04' 22°54' (Faxa Bay)	42	23.x.66
<i>R. batis</i>	144 cm	64°01' 22°55' (Faxa Bay)	45	23.x.66
<i>R. batis</i>	166 cm	" " "	"	"
<i>S. acanthias</i>	79 cm	66°13' 23°18' (Isafjord)	48-61	28.x.66

Every fish was dissected immediately after capture and the organs of the alimentary system were removed and separated. These were then opened, washed and individually preserved, together with their contents, in a formalin acetic saline solution and subsequently examined for parasites. It was hoped that an analysis of the stomach contents of the fish would reveal their diet, but unfortunately most of the *S. acanthias* had regurgitated their food on capture and thus had empty stomachs. Nevertheless, from an examination of those fish which had retained their food, the diet would appear to consist of small Crustacea and Polychaete worms in the smaller specimens, larger fish supplementing a diet of fairly large Crustacea with small fish.

Whilst searching for tapeworms, some specimens of *Otodistomum* (Trematoda; Azygiidae) were recovered from the anterior region of the stomach of two *R. batis*, and several Skate harboured *Calicotyle* (Monogenea; Monocotylidae) in the rectum posterior to the rectal gland. Some small, unidentified Digenetic Trematodes were found in the stomach and spiral valve of *S. acanthias*, and Nematodes occurred throughout the gut of both species of fish.

Altogether, nine species of Cestodes were recovered. These were stained with Gower's paracarmine or aceto-carmine and mounted *in toto*, or were serial-sectioned at a thickness of 15 $\mu$  and stained with Ehrlich's haematoxylin and eosin.

All the specimens, including the type-specimens of the three new species described, are deposited in the collection of the British Museum (Natural History), and their registration numbers are included in the following list.

#### LIST OF CESTODES RECOVERED

##### Order TETRAPHYLLEIDA

##### Family PHYLLOBOTHRIIDAE Braun, 1900

*Phyllobothrium* sp. innom. from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.1-10, 11-12.

*Echeneibothrium dubium* Beneden, 1858, from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.41-60.

*Echeneibothrium minutum* Williams, 1966, from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.61-65.

*Echeneibothrium faxanum* sp. nov. from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.13-20.

*Trilocularia acanthiaevulgaris* (Olsson, 1867) from *Squalus acanthias*, Faxa Bay, Isafjord and Vestermann Is. Reg. no. 1969.2.19.1-40.

Family **ONCHOBOTHRIDAE** Braun, 1900

*Acanthobothrium icelandicum* sp. nov. from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.21-40.

*Acanthobothrium parvum* sp. nov. from *Raja batis*, Faxa Bay. Reg. no. 1969.2.24.251-261.

*Acanthobothrium* sp. innom. from *Raja batis*, Faxa Bay. Reg. No. 1969.2.24.262.

Order TETRARHYNCHIDEA

Family **GILQUINIIDAE** Dollfus, 1942

*Gilquinia squali* (Fabricius, 1794) from *Squalus acanthias*, Faxa Bay, Isafjord and Vestermann Is. Reg. no. 1969.2.24.263-300.

The piked dogfish (*S. acanthias*) was found to harbour only two species of tapeworm, both very common, and one of them, *Trilocularia acanthiaevulgaris*, already having been recorded from Iceland (Rees, 1953). The parasitic fauna of the skate (*Raja batis*) proved to be more varied, with mixed infestations consisting of seven species of Cestodes whose occurrence is perhaps best illustrated in the following table.

TABLE I

Cestode infestations of *Raja batis*

Parasite	Individual specimens of <i>Raja batis</i>				
	48 cm	61 cm	65 cm	144 cm	166 cm
<i>Phyllobothrium</i> sp. innom.			X	X	
<i>Echeneibothrium dubium</i>	X	X	X	X	X
<i>E. minutum</i>		X	X	X	X
<i>E. faxanum</i>					X
<i>Acanthobothrium icelandicum</i>				X	X
<i>A. parvum</i>		X	X		
<i>Acanthobothrium</i> sp. innom.				X	

The Skate, as a host for helminth parasites, has been fairly extensively studied, and so it is somewhat surprising that three new species of Cestodes should have been found during these investigations. A possible explanation for this fact is the lack of knowledge of fish-parasites in Icelandic waters. There do not appear to be any records of the helminths of *Raja batis* from this region, which may mean that the fish is supporting an endemic parasitic fauna that has so far been overlooked. This seems particularly plausible if the habits of the Skate are considered. For instance, these fish do not make long migrations, but remain in the same area throughout their lives, and specimens from Iceland probably never leave Icelandic coastal waters.

## DESCRIPTION OF SPECIES

*Acanthobothrium icelandicum* sp. nov.

(Figs 2-3; Plates 1 and 2)

Material was collected from two skate (*Raja batis*) in Faxa Bay, on 23 October 1966, and consisted of six specimens from one fish and seventeen from the other, three of which were immature forms. In both cases many fragments and apolytic segments were also obtained.

The largest specimen measures 67.4 mm in length and 1.1 mm in maximum width, bearing 140 proglottids, whilst the small immature worms are only just showing signs of segmentation and measure up to 4 mm in length. The terminal proglottid is about 2 mm long and 0.7 mm wide, and the free segments vary from 2.4 to 9.4 mm in length by 0.7 to 2.1 mm in width.

The scolex (Fig. 2a, plates 1 and 2) varies considerably in size, measuring from 0.98 to 1.2 mm in length and from 0.51 to 1.22 mm in width. The four very variable bothridia are divided by two transverse septa into three loculi, of which the anterior

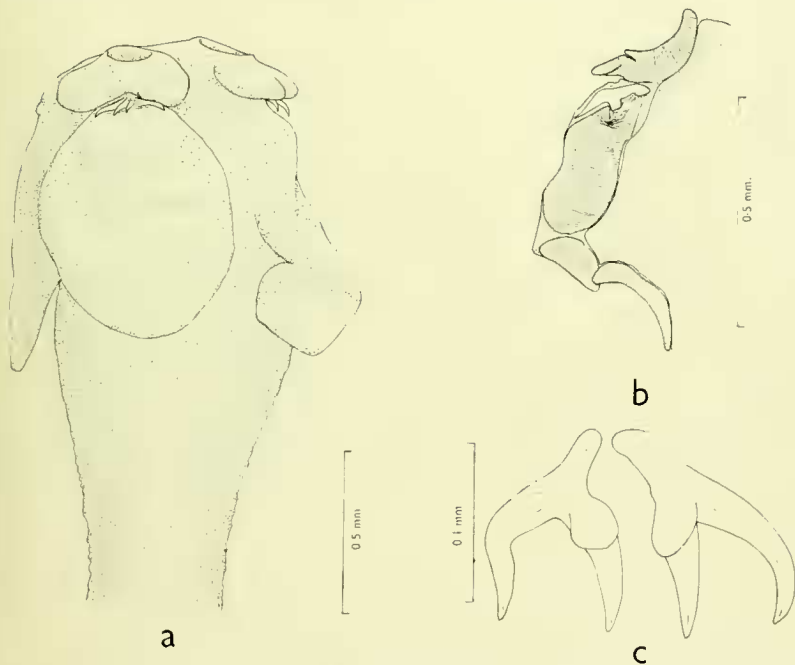


FIG. 2. *Acanthobothrium icelandicum*. (a) Scolex. (b) Longitudinal section of scolex. (c) Hooks.

is usually two or three times the length of the other two. The bothridia measure from 0.52 to 0.79 mm long, by 0.42 to 0.68 mm wide.

Each bothridium is armed with one pair of bifid hooks, measuring 0.12–0.16 mm long, and having a handle of 0.04–0.065 mm, an inner blade of 0.075–0.1 mm and an outer blade measuring 0.084–0.108 mm in length (Fig. 2c). On each bothridium there is an accessory sucker, measuring 0.168–0.23 mm in diameter, situated on a roughly triangular muscular cushion (Plate 1A–B).

The cephalic peduncle ranges from 2 mm to 7.7 mm in length, and when *in situ* is completely buried in the intestinal mucosa of the host, the anterior region bending back on itself to face the site of entry, thus ensuring a very secure attachment. This evokes considerable host-tissue reaction, which is evident in all the specimens of *Acanthobothrium* encountered.

A neck is present (0.36–0.65 mm long), but it is often difficult to distinguish from the base of the cephalic peduncle in specimens which have been stained and mounted *in toto*.

The irregularly alternating genital pores are situated in the posterior half of each segment. There are two layers of longitudinal muscle-fibres. The outer forms an unbroken ring of bundles, each bundle consisting of 2–15 fibres, whilst the inner musculature comprises 7–14 bundles of fibres in the ventral field and 6–10 bundles in the dorsal field, each bundle containing 4–30 fibres. The transverse and oblique musculature is very poorly developed. On each side of the strobila the longitudinal excretory vessels are of almost the same diameter, the dorsal being very slightly narrower than the ventral.

Both genital ducts pass between the longitudinal excretory vessels. The cirrus-sac is globular or pyriform, and ranges in size from 0.1 mm  $\times$  0.046 mm in young male segments to 0.38  $\times$  0.16 mm in mature female segments, attaining dimensions of 0.41 mm  $\times$  0.28 mm in ripe, detached proglottids. The vas deferens coils within the cirrus-sac to form a seminal vesicle, then leaves the pouch to lie between the testes in the median, anterior field of the segment (Fig. 3a). There is a strongly-spined cirrus present (Fig. 3b), which measures 1.09 mm in length and 0.15 mm in diameter at a bulbous swelling near the base (which contains the tightly coiled vas deferens). The cirrus can be very frequently found in a fully extended state in detached proglottids, but not so often in segments along the length of the strobila.

There are between 92 and 114 testes, contained in the area between the excretory canals, with 48 to 59 occurring in the aporal field and 40 to 61 porally (30 to 50 in front of the pore and 9 to 15 postporally). In transverse section the testes are found to occupy most of the vertical field between the longitudinal muscle-bands. In later mature segments the vasa efferentia leading from the testes become heavily swollen with sperm and reach proportions sometimes greater than the testes themselves.

An anomalous condition in which the number of testes on one side of the segment was very reduced, occurred not infrequently in one particular worm. In the same strobila a proglottid containing an additional, inverted, female system with no opening to the exterior, was encountered. (Fig. 3a).

A short distance behind the female genital pore there is a well-developed muscular vaginal sphincter (Fig. 3b). The thick-walled vagina passes ventrally and slightly

anteriorly to the cirrus-pouch, turning in mid-segment to run back to the oötype, situated behind the central portion of the ovary.

The two unequal lobes of the ovary are connected midway along their length by a long isthmus, giving the organ an 'H'-shaped appearance, with the posterior arms of the 'H' turning inwards to the middle of the segment (Fig. 3a). It is contained in the area within the longitudinal excretory vessels, and occupies the whole of the depth of the field between the longitudinal musculature, except for the connecting isthmus, which spans the ventral field of the segment.

The vitellaria are disposed in two continuous longitudinal rows laterally to the excretory canals, being broken only by the genital ducts on the poral side. The uterus initially has many small lobes, which grow until they occupy the whole of the segment. The rounded eggs measure 0.018–0.022 mm and contain embryos measuring 0.01–0.014 mm in diameter.

These specimens are very similar in many respects, especially in the shape and size of the hooks and the number of testes, to *A. septentrionale* Baer & Euzet, 1962. This species was erected to represent *A. coronatum* (Rud., 1819) of Johnstone, 1906, from *R. clavata* and *R. batis*; *A. ijimai* Yoshida, 1917, of Southwell, 1925, from *Raja* spp.; and *A. coronatum* (Rud., 1819) of Linton, 1925 (*pro parte*). However, according to their respective authors, all these worms have three accessory suckers in front of

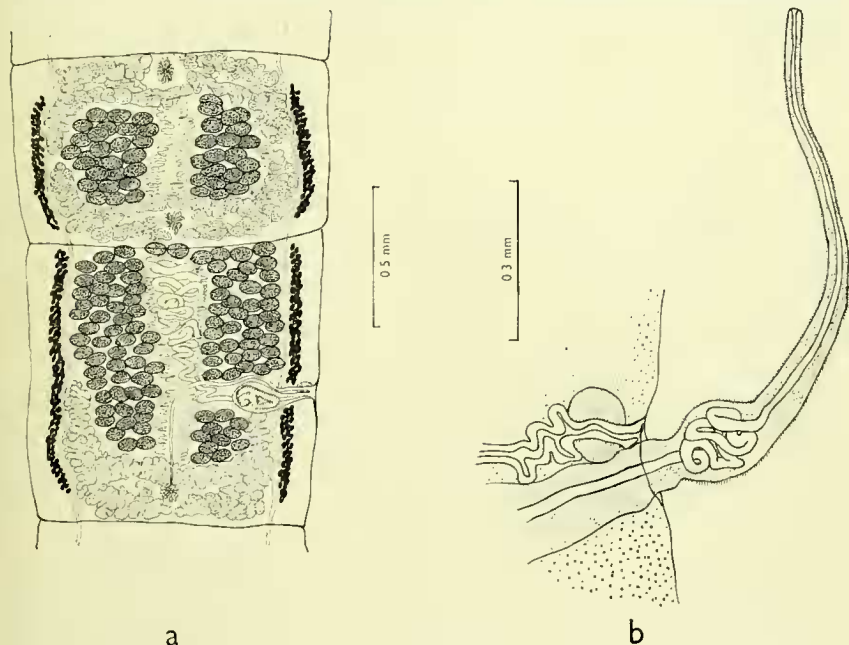


FIG. 3. *Acanthobothrium icelandicum*. (a) Portion of strobila containing an atypical segment with an additional, inverted set of female organs, and a typical mature segment. (b) Extruded cirrus, in transverse section.

each bothridium, a character which Baer & Euzet do not mention in their description. The present material, when examined *in toto* under the light microscope, also appeared to have three accessory suckers, but on subsequent examination under the scanning electron microscope this condition was not confirmed. Instead there appeared a triangular structure provided with an anteriorly-disposed sucker (Plate 1). Transverse sections showed the structure to be very muscular, and substantiated the presence of a single accessory sucker (fig. 2b). Rees and Williams (1965) interpret the prebothridial structures found in *A. coronatum* as muscular cushions, an interpretation which seems most applicable in this case. Further features in which *A. septentrionale* differs from *A. icelandicum* are the 'U'-shaped rather than 'H'-shaped ovary, and the apparent lack of a vaginal sphincter. Southwell (1925) in his description of *A. ijimai*, states that the dorsal excretory vessel is wider than the ventral, an unusual feature which does not occur in *A. icelandicum*.

The only other species of *Acanthobothrium* which agree in the size of the hooks and number of testes with the material collected from Iceland are *A. robustum* Alexander, 1953, from *Rhinobatos productus*, Southern California, and *A. dasybati* Yamaguti, 1934, from *Dasybatus akajei*, Japan. The former differs from the species described here in having an accessory spur to the hooks, and the latter by the lack of an accessory sucker (and also, in an amended description by Yamaguti (1952) in the number of testes). Both species occur in totally different hosts and in localities widely separated from the distribution of *Acanthobothrium icelandicum*.

### *Acanthobothrium parvum* sp. nov.

(figs 4-5)

Only a few specimens of this worm were retrieved from the spiral valve of two Skate (*Raja batis*) from Faxa Bay on 21 and 22 October 1966. The material consists of only two whole worms, but includes five fragments with scoleces attached, together with a few apolytic segments.

The worms are of small size for the genus, the largest measuring 19.3 mm in length, and the maximum width varies between 0.35 and 0.56 mm. The highest number of segments counted in a single strobila is 85.

The dimensions of the scolex vary with the state of contraction of the worm, the diameter ranging from 0.54 mm to 0.73 mm and length from 0.6 mm to 0.76 mm (fig. 4a). The four bothridia measure 0.456-0.564 mm. long by 0.3-0.41 mm wide. There is quite a considerable variation in the comparative sizes of the three very muscular loculi, although in the present material the middle loculus is the smallest, and the most anterior is usually fractionally larger than the posterior. The bothridial armature consists of one pair of bifid hooks to each bothridium (fig. 4b). The hooks measure between 0.116 mm and 0.144 mm in length, the measurement being taken from the base of the handle to the tip of the outer blade. The handle is 0.04-0.06 mm long, the inner blade 0.08-0.108 mm and the slightly larger outer blade 0.08-0.11 mm in length. Each bothridium is surmounted by a very muscular cushion bearing a single accessory sucker which varies in diameter between 0.1 and 0.16 mm.



There is a long, unarmed cephalic peduncle present, 1.4–3.5 mm in length, and segmentation begins from 0.2 mm to 3.5 mm behind this structure.

The irregularly alternating genital pores are situated approximately midway along each segment. The outer longitudinal musculature is very well developed, forming a complete circle of bundles each containing up to twenty fibres, and very closely applied to the body-wall of the worm. The less well-developed inner musculature consists of 5–10 bundles, each having up to 35 fibres, in both the dorsal and ventral layers.

The ventral excretory canal is very much wider than the dorsal, the genital ducts passing between the two longitudinal canals. The cirrus-sac is somewhat fusiform in mature segments (fig. 5a), but attains a considerably larger size and becomes rather more oval or pyriform as the segments develop further (fig. 5b). It may only measure 0.022 mm in diameter and 0.12 mm in length in early proglottids, but reaches a diameter of 0.172 mm and a length of 0.28 mm with further maturation. The cirrus-sac contains a coiled vas deferens, swollen with sperm to form a seminal vesicle, which on leaving the pouch turns forwards to lie in the anterior median field, where it becomes very convoluted and may occupy much of the region between the excretory canals. The protracted cirrus is large, measuring over 0.26 mm in length and 0.052 mm in diameter, and is covered with spines up to 0.01 mm long.

There are usually between 64 and 79 testes in each proglottid (although in one case only 58 and in another 85 are present), restricted to the area between the excretory vessels and in front of the ovary. They are distributed with 31–44 in the aporal field and 26–39 in the poral half of each segment, with 5–9 testes situated postporally.

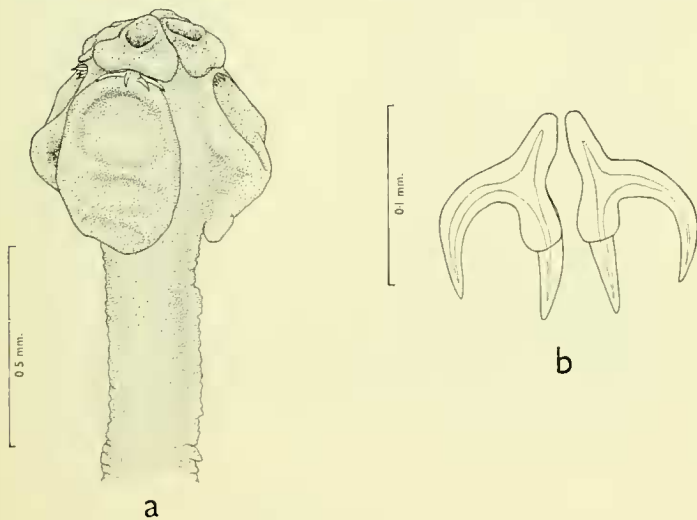


FIG. 4. *Acanthobothrium parvum*. (a) Scolex. (b) Hooks.

The vagina is very muscular, and in transverse sections can be seen to lie dorsally to the cirrus-sac. It crosses over the external vas deferens behind the cirrus pouch, to pass back to the oötype in the hindermost region of the ovary. The 'H'-shaped ovary appears to be bi-lobed, of which the aporal lobe is sometimes longer, extending beyond the cirrus-sac. Early in its development the ovary occupies from a quarter to a third of the posterior region of the segment, but may expand to over half the proglottid in terminal segments. Initially the uterus is saccular with a few lateral indentations but in later segments attains greater proportions, becoming much lobed, and is difficult to distinguish from the seminal vesicle.

The vitellaria are densely packed into the region outside of the excretory canals. They are round to oblong and form one or two rows.

The terminal segment varies between  $1.42 \times 0.51$  mm and  $4.1 \times 0.9$  mm, the latter being the stage at which the testes are beginning to atrophy and the uterus is expanding, which appears to be the furthest state of maturation attained whilst still attached to the strobila (fig. 5b).

Amongst the apolytic segments collected there are none that have reached the fully gravid stage, so that no record of the egg size can be obtained, but in the more

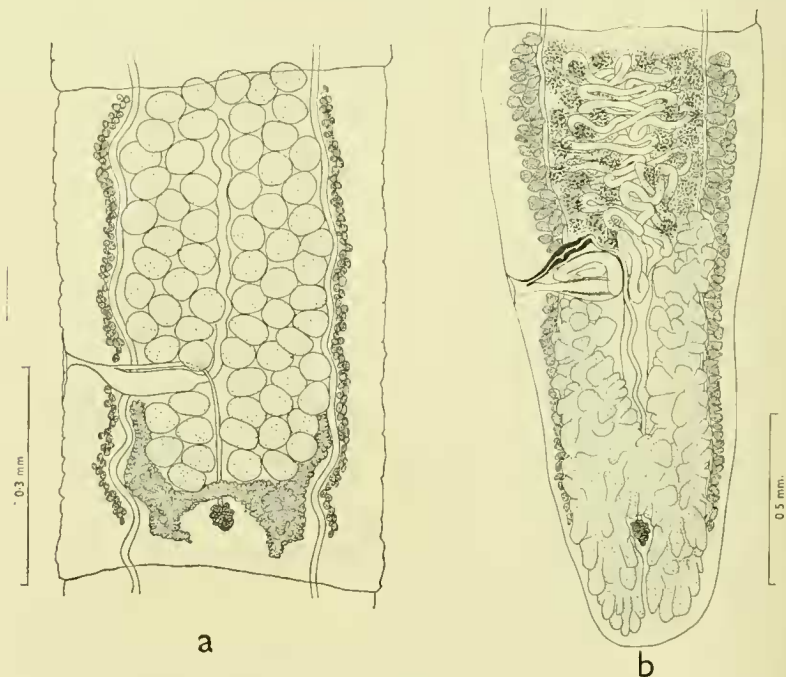


FIG. 5. *Acanthobothrium parvum*. (a) Mature segment. (b) Terminal segment, in which the testes are beginning to atrophy.

mature free proglottids, measuring about  $4 \times 1$  mm, the developing eggs measure approximately 0.02 mm in diameter.

The over-riding diagnostic characters of this small worm are the number of testes per segment, and the size of the bothridial hooks, a combination which cannot be found in the descriptions of any other species of *Acanthobothrium*.

A species commonly found in the Skate is *A. rajaebatis* (Rud., 1809). Although this worm has a similar range in the number of testes to *A. parvum*, it is a much larger worm reaching 60 mm in length and has proportionally greater dimensions throughout, the hooks alone measuring up to 0.30 mm long.

Yamaguti (1952) in his redescription of *A. dasybati* Yamaguti, 1934, (from a number of Japanese species of rays) gives the worm a comparable number of testes with the species described here, but the hooks have very much shorter prongs, the ovary is quadrilobed, and he states that there is no accessory sucker (although signs of one can be seen in his figure). Also *A. dasybati* has not been recorded from rays in European waters nor from *Raja batis*.

*A. maculatum* Riser, 1955, from *Aetobatus californicus*, California, agrees in many respects with the morphology of *A. parvum*, but differs in having a very long anterior loculus to each bothridium, a very small cirrus-pouch, and different proportions to the hooks, quite apart from the differences in host and distribution.

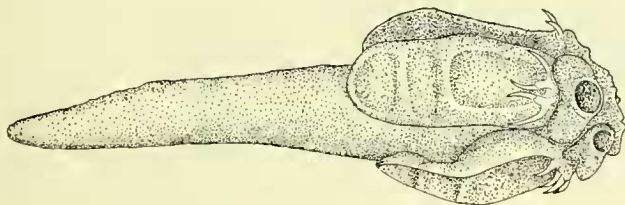
Very similar hooks to those described here can be found in *A. batailloni* Euzet, 1955, from *Myliobatis aquila* at Sète, but this particular species has small accessory suckers, a spiny neck and only 37-64 testes.

Neither Goldstein (1967), nor Williams (1969), in their respective publications on the genus *Acanthobothrium*, includes any worm comparable with *A. parvum* amongst the many species described, and there can be found nowhere in literature examined any reference to a worm from Elasmobranchs that fits the description of *A. parvum*.

### *Acanthobothrium* sp.

(fig. 6)

One immature specimen 1.8 mm long was collected from *Raja batis* in Faxe Bay on 23 October 1966.



0.5 mm.

FIG. 6. *Acanthobothrium* sp.

The scolex, bothridia, and hooks, together with the overall size, are the few morphological characters available in this young worm. The bothridia measure 0.39 mm to 0.4 mm in length, and the hooks are from 0.108 to 0.12 mm long. The handle measures 0.046–0.056 mm, the inner blade 0.072–0.074 mm and the outer blade 0.074–0.08 mm.

There is some speculation as to the stage in development at which the hooks of *Acanthobothrium* and allied genera stop growing, and for this reason the above specimen has not been allotted to a new, or previously-described species.

*Echeneibothrium minutum* Williams, 1966

(figs 7 and 8a)

Many complete worms, together with several fragments, were found in four *Raja batis* caught in Faxe Bay on 22 and 23 October 1966. The worms are slightly larger than the specimens described by Williams, measuring between 1.29 mm and 3.75 mm in length (one specimen, however, reaches 5.48 mm) as opposed to 2 mm for Williams' material. There is a corresponding increase in the number of segments (up to thirty instead of ten), the myzorhynchus is fractionally larger, and the spine-covered, muscular bothridia may be a good deal longer. In the original description of *E. minutum* the bothridia are quoted as being 0.27 mm long, but are figured at about 0.5 mm. In the present material the bothridia are usually between 0.5 and 0.7 mm in length, but can reach a size of 0.9 mm, varying in shape and size quite considerably

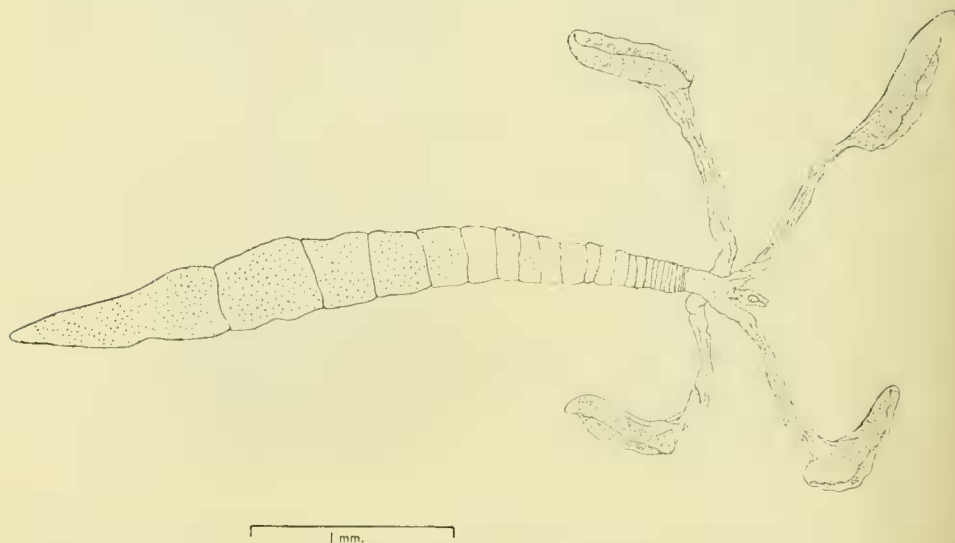


FIG. 7. *Echeneibothrium minutum*.

according to the degree of contraction or relaxation of the musculature at the time of fixing the worms. *E. minutum* has twenty loculi to each bothridium, as indeed do all the worms in this collection, but there appears in several instances to be only eighteen loculi on at least one bothridium of a worm whose other bothridia most definitely possess twenty, and in one case twenty-two loculi are apparent. In many other specimens the bothridia are so relaxed that it is very difficult, even with these structures individually mounted, to distinguish septa at all, let alone count the loculi with any degree of accuracy.

All the other features of this worm correspond closely with the original description of *E. minutum*, although a greater variation in the number of testes occurs, ranging from nine to fifteen per segment. Within the present material it is possible to divide the worms into two groups according to the number of testes. Specimens from three fish have 10-14 testes, whilst those from a fourth Skate have only between 9 and 11 per segment. This single character, however, does not justify the separation of the two groups as they are otherwise morphologically indistinguishable.

Two species of *Echeneibothrium* that have a comparable number of loculi to the bothridia and a similar number of testes to these specimens, are *E. maculatum* var. *exiguum* Euzet, 1959, and *Echeneibothrium* sp. Williams, 1966. However, they are larger worms, the former measuring 3-10 mm and the latter up to 7 mm in length, and occur in a different definitive host, *Raja clavata*.

Of the other recorded species of *Echeneibothrium*, there are several with similar proportions in the bothridia to the Icelandic material, but they all have a considerably higher number of testes, usually more than twenty per segment, and are altogether larger worms.

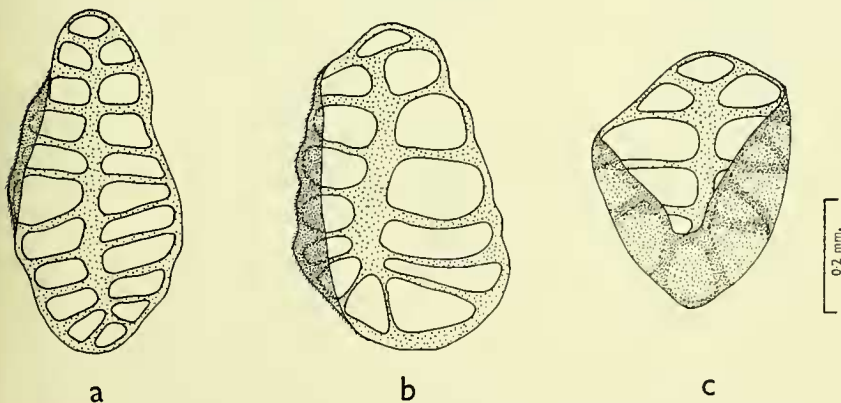


FIG. 8. Diagrammatic comparison of the bothridia of the three species of *Echeneibothrium* encountered: (a) *E. minutum*. (b) *E. faxanum*. (c) *E. dubium*.

*Echeneibothrium faxanum* sp. nov.

(figs 8b and 9)

*Echeneibothrium* sp. Williams, 1966.

This species was found in the spiral valve of only one Skate (*Raja batis*) caught in Faxa Bay, and the total collection is represented by only a few complete specimens and several fragments. The largest worm examined attains 14.63 mm in length and the smallest 10.5 mm. The number of segments varies from 27 to 42 and the maximum width recorded is 0.3 mm.

The specimens can be readily distinguished from the other worms present by the enormity of the myzorhynchus. When contracted this structure swells the scolex to a diameter of up to 0.28 mm and a length of 0.51 mm (fig. 9a), and when extruded the total length of the myzorhynchus may be up to 0.92 mm. The large terminal sucker on the fully-extended myzorhynchus measures 0.36–0.383 mm long by 0.22–0.28 mm in diameter (fig. 9b).

The four bothridia are borne on spiny stalks up to 0.9 mm long, and vary from 0.54 to 0.76 mm in length by 0.24 to 0.39 mm in width, with their external surfaces covered with small spines. There are 14 loculi to each bothridium, comprising one anterior, one posterior and twelve lateral loculi (fig. 8b). It is difficult to differentiate between the base of the tapering scolex and the beginning of the short neck, nevertheless, segmentation begins some 0.3 mm behind the scolex.

The genital pores are lateral and irregularly alternating, as is usual for the genus, and open in the posterior third of the proglottid. There are two pairs of longitudinal excretory canals, the ventral being wider than the dorsal, with no cross-connections readily visible.

The cirrus-sac is pyriform and contains a large spiny cirrus (in every worm examined the cirrus was invaginated) followed by a coiled, and much swollen with sperm, vas deferens, which, on leaving the pouch becomes further convoluted and lies in the median field of the segment. When fully developed the cirrus-sac extends across the segment to reach the aporal excretory canals, and measures 0.18 mm long by 0.09 mm wide.

In early proglottids the testes are spherical with a diameter of 50–70 $\mu$ , but increase in size with further maturation, adopting a more oval outline and measuring up to 120  $\times$  85 $\mu$ . They are disposed in two rows between the excretory vessels and occupy the anterior two-thirds of each segment (fig. 9c). The usual range in the number of testes is between 20 and 26, although there may be as few as nineteen, and in one case 27 were counted.

The vagina is anterior and slightly ventral to the cirrus-sac, turning abruptly in mid-field to run posteriorly to an oötype situated in the region behind the isthmus of the ovary. The ovary itself lies within the area bordered by the excretory canals in the posterior  $\frac{1}{3}$ – $\frac{1}{2}$ rd of the segment and consists of four longitudinal lobes, all roughly equal in length, connected almost terminally by a short isthmus. This gives the ovary almost a 'U' shape rather than the 'H' configuration more commonly encountered in the genus. In all segments examined the uterus is tubular and rather indistinct, not having attained any degree of development, and runs the

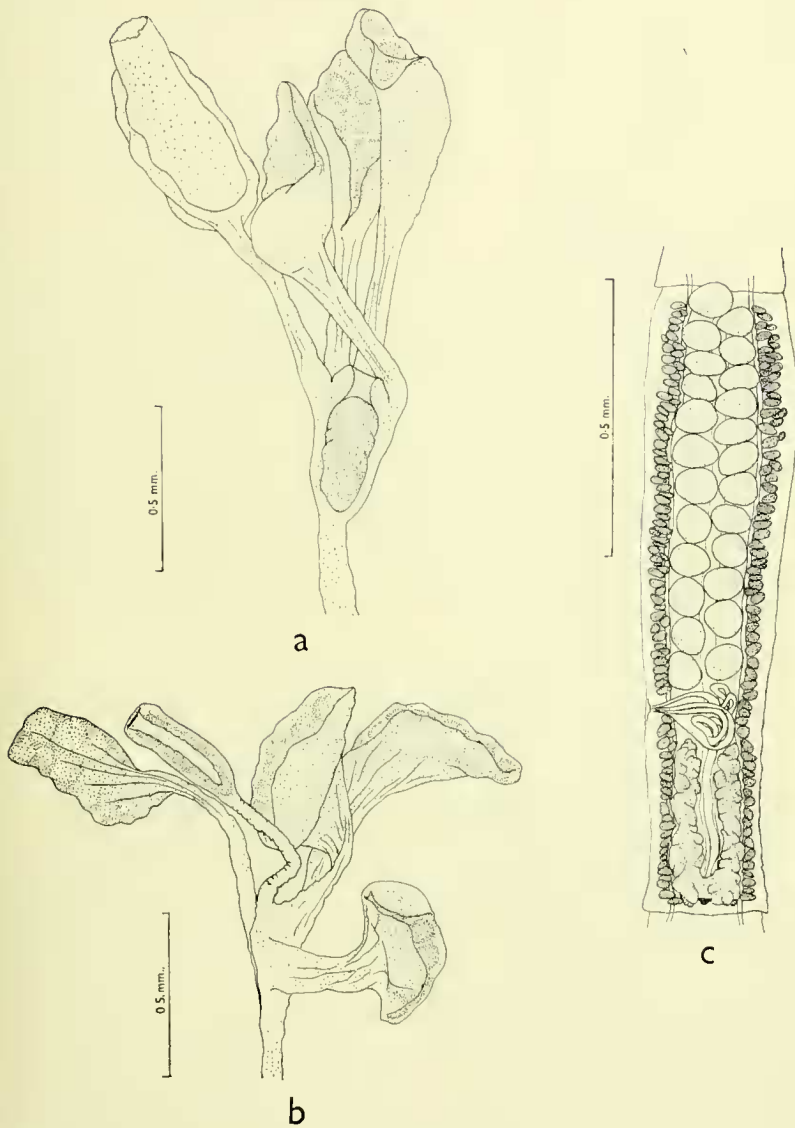


FIG. 9. *Echeneibothrium faxanum*. (a) Scolex with contracted myzorhynchus. (b) Scolex with myzorhynchus extruded. (c) Mature proglottis.

length of the median line of the proglottid in the ventral field. The compact vitellaria are roughly circular to oval measuring in the region of 0.05 mm in diameter in mature segments. They are marginal, lying in one or two longitudinal rows in the area outside the excretory canals.

The terminal segment varies from 1.82 to 3.56 mm in length with a maximum width of between 0.2 and 0.3 mm, and contains fully-mature male and female reproductive organs.

No free proglottids were retrieved which could be allotted to this species with any degree of certainty, consequently the morphology of the gravid segments and eggs of this worm remain unknown.

*Echeneibothrium faxanum* has a very similar morphology in many respects to *E. variabile* Beneden, 1849, but differs in having only 14 loculi, as opposed to 16 in the latter, in the characteristic shape and comparatively small size of the myzorhynchus, and in its occurrence in the spiral valve of *Raja batis* (*E. variabile* is more commonly found in *R. clavata*). Euzet (1959) describes a variety of *E. variabile* from *R. batis* with a comparable number of loculi to *E. faxanum*, but the huge size of the myzorhynchus renders it unlikely to be synonymous with the species described here. *E. demensiae* Euzet, 1959, has affinities with *E. faxanum*, particularly in the similar shape and size of the myzorhynchus, but can be discounted as there are eighteen distinct loculi to each bothridium. Finally, Williams (1966) describes a worm from *R. batis* caught in British waters as *Echeneibothrium* sp., which although it is slightly smaller, corresponds so closely with these specimens of *E. faxanum* that it is almost certainly the same species.

### *Echeneibothrium dubium* Beneden, 1858

(figs 8c, 10 and 11)

This is by far the most common worm encountered, inhabiting in large numbers the spiral valve of every specimen of *Raja batis* caught in Faxe Bay.

The worms measure from 3.55 mm to 15.7 mm in length, and have from 35 to over 130 segments, rather more than is usual for this species.

The delicate bothridia may have their external surfaces covered with many small spines, and have a characteristic pyriform outline with the posterior border cup-shaped (fig. 8c). There are 14 distinct loculi. The myzorhynchus when fully extended is long and slender with a small sucker at its tip (fig. 10a), but when retracted assumes a vase-like appearance (fig. 10b).

Apart from the very wide range in the number of testes, the internal anatomy of these specimens tallies closely with all descriptions of *E. dubium*. There are between 11 and 22 testes per segment in these worms from Iceland. Initially it was thought that this large variation must be due to the presence of more than one closely-allied species whose range in testes overlap. However, on counting the testes from every segment of a number of randomly selected worms, it can be seen (fig. 11) that although the highest variation in the testes per individual worm is only five, the



shallow gradation in numbers throughout the whole group extends this range to ten, indicating that no clear-cut distinction can be made between the specimens.

Several species of *Echeneibothrium* have 10 loculi to their bothridia and have a testes number which falls within the range of this material. *E. myzorhynchum* Hart, 1936, *E. dolichoophorum* Riser, 1955, and *E. macrascum* Riser, 1955, all come into this category, but quite apart from numerous morphological differences, all

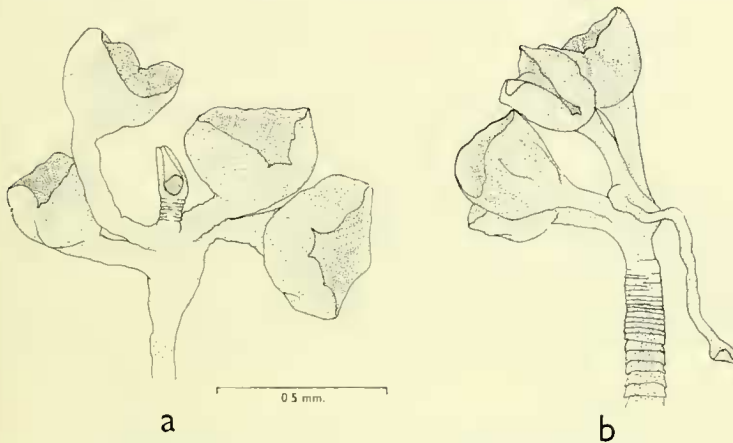


FIG. 10. *Echeneibothrium dubium*. (a) Scolex with contracted myzorhynchus. (b) Scolex with myzorhynchus extruded.

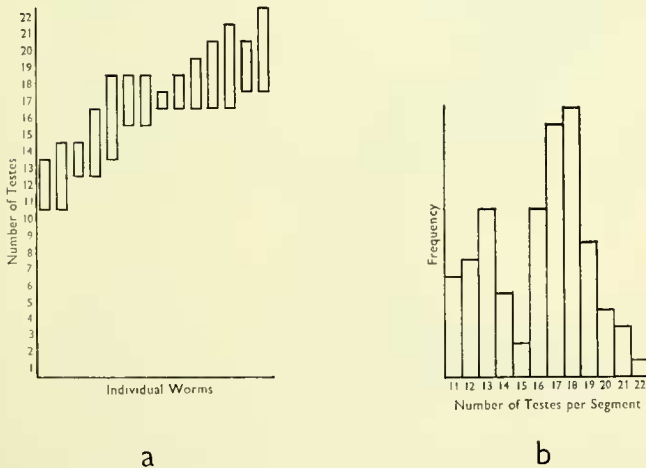


FIG. 11. *Echeneibothrium dubium*, showing the variation in the number of testes per segment. (a) Range within a group of individuals. (b) Frequency of testes per segment in the same group.

three species occur in Rays found on American coasts (*R. binocularata*, *R. rhina* and *R. montereyensis*, respectively), and are therefore unlikely to be found in *R. batis* off Iceland.

Other worms that have some similarities to this material are *E. maculatum*, *E. minimum* and *E. variabile* (pro-parte), with which species in fact *E. dubium* has at times been synonymized by various authors. However, the specimens collected from Iceland cannot reasonably be ascribed to any of these species, and the author can but only agree with Williams' (1958) conclusions in his very adequate elucidation of the status of *E. dubium*.

*Trilocularia acanthiaevulgaris* (Olsson, 1867)

(fig. 12)

All seven specimens of *Squalus acanthias* yielded examples of this worm, either from the stomach, or spiral valve, or from both organs. The worms are all immature with no signs of segmentation, and are shaped rather like an inverted pyramid, with the broadest region at the scolex.

Those specimens from the spiral valve measure from 2 mm to 7.5 mm in length, whereas the smaller specimens found in the stomach only range between 1.8 and 2.4 mm.

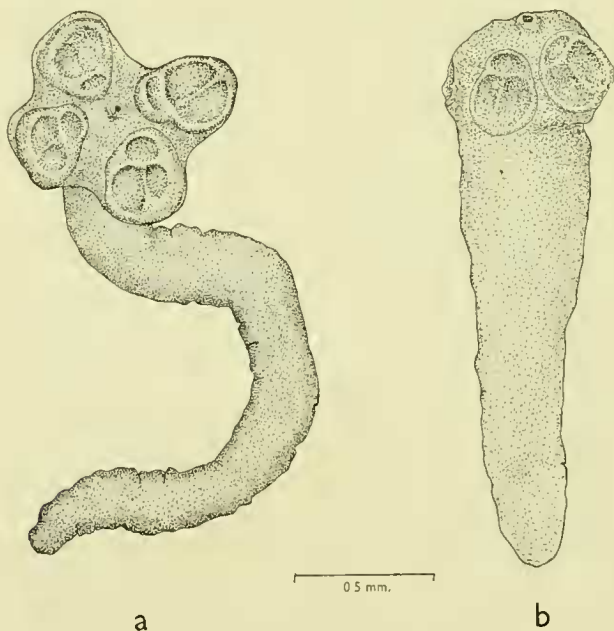


FIG. 12. *Trilocularia acanthiaevulgaris*. From the spiral valve (a) and stomach (b) of *Squalus acanthias*.

The normal variation in scolex diameter is from 0.7 mm to 0.85 mm, although in one worm the measurement is 1.0 mm. The bothridia have the characteristic tripartite shape, with one anterior, and two adjacent posterior loculi (fig. 12). The anterior loculus measures 0.06–0.17 mm  $\times$  0.14–0.24 mm, whilst the posterior region of the bothridium is 0.2–0.3 mm in width by 0.14–0.24 mm in length, and is divided into two equal loculi by a vertical septum. There is a small terminal sucker to the scolex, with a diameter of between 0.06 mm and 0.11 mm.

In one dogfish, the only specimens to be found in the spiral valve were three mature free segments with the characteristic spiny anterior region and posteriorly situated cirrus-sac and genital pore. There were, however, entire immature worms in the stomach of this fish. Alexander (1963) has also recorded the occurrence of only free proglottids on two occasions from dogfish in New Zealand.

This worm has been assigned to a number of genera, being originally described by Olsson as *Phyllobothrideum acanthiae-vulgaris*, but later (1869) it is included by him in the genus *Trilocularia* Olsson. Since then this species has been transferred to the genera *Monorygma* Diesing, *Phyllobothrium* Beneden, and then back to *Trilocularia*.

The distribution of *T. acanthiae-vulgaris* appears to be very widespread, being recorded from *Squalus acanthias* in New Zealand by Alexander, from Southern France by Euzet; there are numerous records of the worm from British waters, and Rees (1953) has described specimens from the East coast of Iceland.

### *Phyllobothrium* sp.

Two immature specimens both measuring approximately 6 mm in length, and five adult worms 27–32 mm long with a maximum width of 2 mm, were found together with many apolytic segments in the spiral valve of *Raja batis* from Faxe Bay. Another Skate from the same locality yielded a further two immature specimens which measure 2 mm and 2.5 mm in length and show no signs of segmentation.

Unfortunately, the contracted condition of the preserved worms renders positive identification beyond the generic level virtually impossible, and so the worms have not been ascribed to any previously-recorded species of *Phyllobothrium*.

### *Gilquinia squali* (Fabricius, 1794)

These worms were found with their scoleces firmly embedded in the mucosa of the anterior region of the spiral valve of four specimens of *Squalus acanthias* from Faxe Bay, Isafjord and North of the Vestermann Islands.

The length of the worms ranges from 13.1 mm to 34.8 mm, having a maximum width of between 1.05 and 1.65 mm, and bearing up to 51 segments.

In general morphology these specimens correspond so closely with the definition of *G. squali* given by Dollfus (1942) in his monograph on the Tetrarhynchs, that any further description here is unnecessary.

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